

Mechelectric



Volume 24

April - 1966

No. 5



THE GEORGE WASHINGTON UNIVERSITY

APRIL 1966



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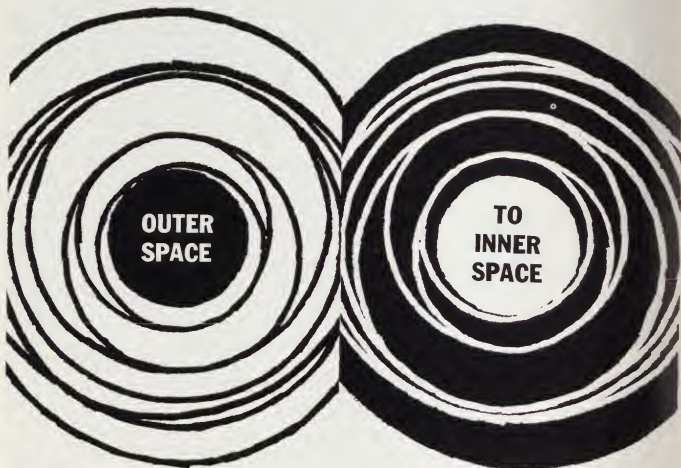
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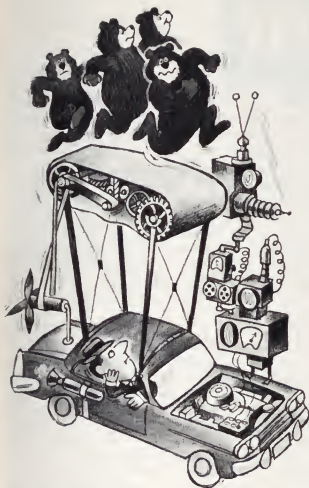
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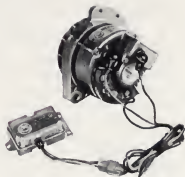
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*An electronic system that maintains a consistent, reliable energy supply for the car's electrical equipment.

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MOTOROLA

THE ENGINEER'S ROLE IN SOCIETY



On this page, during this year, we have taken several rather myopic glances at the personal satisfactions, remunerations and rewards of the engineering profession available to the young graduate engineer. For a sobering change of pace, let's give a few muddled thoughts to the other side of the picture . . . the responsibility of an engineer not only to himself and his profession but to society as a whole. Headaches incurred in this sobering process are probably earned and deserved.

In this world of rapidly increasing entropy the contemporary engineer must give much more mature thought to the effect of his work and attitude on society. Due to the increasing influence of engineering work the modern engineer must reevaluate his relationship to the increasingly interdependent and complex world. Mr. R. E. Engdahl stated in a "Mechanical Engineering" article of a few years ago, ". . . the engineer, to be really professional, must carry constantly in mind a concern for what effects his creative efforts will have on his fellow man. Within his limited power to influence or act, he must speak out and inform and advise those who control the results of his work so that maximum benefit and minimum distress to mankind and his environment will result. . . . The practicing engineer, however skilled in applying science, who takes a narrow unprofessional view of the total consequences of his efforts contributes toward potential world disaster."

R. B. Smith, past-president of A.S.M.E., wrote in another recent "Mechanical Engineering" article — "Now 50 percent of all scientists in the United States are supported by national, state and local government funds, with their efforts patiently directed to goals determined by political reasoning and purpose. . . . Government appropriations for research and development have increased more than 200 times since 1940, until they now total \$15 billion a year. This sum is three times greater than the development expenditure for the whole of the period of World War II, . . ." It is frightening to contemplate our increasingly complex technological society run by people not well versed in the technical sciences. By the very nature of their educational background those in government cannot know the implications or consequences of scientific advances. It is rather impossible to expect a liberal art major to obtain a working knowledge of science and engineering. It is imperative that the engineer and scientist develop an interest in and become involved in politics and humanity.

By the very nature of his profession the modern engineer is the interpreter of science for the rest of society. But more than simply an interpreter the modern engineer is the obvious motive force for shaping and guiding society in the coming technical age. Due to his development of a highly ordered, logical thought process, his education into the most complex technical modern disciplines, and his constant practice of the scientific method of efficient decision making; the modern engineer provides the potential for the future social leadership.

Saying in print that engineers are the future leaders of society sounds as egotistical as the famous flea crawling up an elephant's leg with romance in mind. But unlike our soul mate, the flea, the modern engineer does have the necessary equipment to work minor miracles. With his logical mental processes, technical knowledge and decision making capabilities coupled with a sincere interest in and a knowledge of the needs and interests of society the engineer can indeed provide the necessary leadership. The first stirrings of this "new breed," to use a threadbare phrase, can be seen in the trend toward business managers with engineering backgrounds and the fantastic interest and increase in enrollment in Engineering Administration across the country.

The plaintive cry of educators, liberal arts majors and other such low life is . . . "engineers are too independent, specialized and too uncooperative." To be sure, an engineer has to crack his brain open to absorb all the magical formulae thrown at him. But to truly fulfill the definition of engineering, . . . the application of science to the efficient conversion of natural resources for the benefit of mankind," the graduate engineer must become involved with the needs of society and continue his education not only in the technical fields but in the humanities as well. He must be proficient in his work but he cannot neglect the far reaching effect of his work.

The young engineer does indeed have the world by a soft and tender spot. Whether he squeezes for his own benefit or leads it gently into a better age for all mankind is a direct function of how well he fills the role of a true man as well as an engineer.

Mecheleciv



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COVER

This month's cover is a Norvick-Moder ball model of diffraction patterns produced by shining laser light through a reduced photo negative of the ball structures.

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STUDENT COUNCIL REPORT

Paul Johnson is a junior majoring in electrical engineering and holds a Trustees' scholarship. He received the Sigma Tau Award for the Outstanding Freshman in the Engineering School for 1963-64, and is a member of Tau Beta Pi and IEEE. He has served as Chief Engineer of campus radio station WRGW and was elected to the Student Council in a close three-way race in February.

by Paul Johnson



I wish to thank Millard Carr, Don Vespia, and the Mecheleciv for allowing me to write this column. Now that I have this opportunity, I only hope that what I write will be at least somewhat enlightening.

ACTIVITIES FEE

Of course, most students know by now that the Board of Trustees, on President Elliott's recommendation, chose not to levy an activities fee next year. About two weeks before this decision, the Student Council had gone on record in favor of "an activities fee." I chose to abstain on this vote, and I am using some of this space to explain why I did so.

First of all, as to why I did not vote "no," I sincerely believe that a properly administered fee could be of general benefit to the student body, including engineering students. The position which I have taken actually differs very little, if any, from that taken last fall by the Engineers' Council in a letter to President Elliott. The Council then stated that it would go along with a fee, albeit reluctantly, if certain conditions were met. These conditions included improved financial management and accounting procedures for the Student Council, abolishment of Campus Combo, and better availability of the Cherry Tree. I fully concur with all of these conditions, and, in fact, so does most of the Student Council. Moreover, certain steps have already been taken to improve the Council's financial operations.

The reason I did not vote "yes" is that voting for "an activities fee" would, I feel, be somewhat like signing a blank check. I don't want to pay something for nothing any more than anyone else does. However, I do believe that, under the right circumstances, some activities fee could be advantageous. I simply want to keep an open mind and see what specific ideas come from the administration. That is when the decision must be made.

The proposal for fees which was discussed by Dean of Men Paul Bissell at the Student Council meeting on March 2 was just that, a proposal. As stated, it would include a \$5 health fee, a \$10 athletic fee, and a \$10 activities fee. This proposal was NOT what the Council was voting on that night. It was simply a possible plan, one which was prepared largely by Dean Bissell and Dean of Women Virginia Kirkbride and has been submitted to Dr. Elliott for consideration. At this point, it is important to state that any proclamation of an activities fee will not come from the Student Council, but from the administration and the Board of Trustees.

I do not claim that my feelings on this subject necessarily indicate those of a majority of my constituents. No person or group of persons can legitimately claim to know the feelings of a majority of the engineering students. However, I do claim most vigorously that, in abstaining as I did, I was exercising my responsibility and my trust as I saw it, and that I am trying to do my job in a manner which will serve the best interests of my constituents.

UNIVERSITY DEVELOPMENT

When this column was originally written, about March 12, it opened with a paragraph which read as follows: "The month between the writing of this column and its appearance promises to be one of unusual interest and importance for the University. Consequently, some of the material included herein may be outdated or insignificant when it appears, but, at the time of writing, it is relevant and important." The prediction I made at that time came true in an even bigger way than I had expected, and fortunately it came true in time for me to do some rewriting.

When the original column was written, student unrest over promises made and broken by past administrations and over seeming, and, in some cases, real, stagnation of University programs was again manifesting itself. Students had rightfully become restless because these projects were still only in the planning stage. They wondered just where their money was going, especially the additional money put into the annual tuition raises, another of which has been instituted for next year.

This desire for understanding was the basis for a letter sent on March 11 to President Elliott and signed by all Student Council members. This letter asked for a detailed, specific, clear delineation of the reasons for the new tuition raise, for the establishment of a four-year tuition contract, or, at least, a four-year projection of finances informing the student of tuition raises he can expect, and for expansion of the financial aid program. One week after this letter was sent, after the Trustees' meeting on March 17, Dr. Elliott replied to the Council's letter. In his reply, he provided figures relating to the tuition raise, announced that the Comptroller's office is working on a four-year financial projection to go into the University catalogue, and stated that financial aid funds had been increased by \$80,000. In addition, Student Council President Rick Harrison has appointed a committee of Council members to maintain contact with Dr. Elliott on issues concerning the students.

—Continued on page 11

THE MECHELECV

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*David Tenniswood
R.S., Michigan State Univ.
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Opportunity comes early at Ford Motor Company. Graduates who join us are often surprised at how quickly they receive personal assignments involving major responsibilities. This chance to demonstrate individual skills contrasts sharply with the experience of many young people entering the business world for the first time. At Ford Motor Company, for example, a graduate may initiate a project and carry it through to its final development. One who knows is David Tenniswood, of our research staff.

Dave joined Ford Motor Company in July, 1961.

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The experience of Dave Tenniswood is not unusual. Ford Motor Company believes that early incentive is fundamental to individual growth and a successful career. If you are interested in a job that challenges your abilities and rewards enterprise, we urge you to contact our representative when he visits your campus.



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Douglas MacDonald is a full time graduate student working toward his Master of Science degree under a N.A.S.A. Engineering Traineeship. He is the president of the Tau Beta Pi Honor Society and was active in Sigma Tau as an undergraduate.

After three years of an extensive and exhaustive study, the American Society for Engineering Education has published a preliminary report on the "Goals of Engineering Education."¹ This report is the response to a request by the Engineers' Council for Professional Development that the American Society for Engineering Education conduct a study of engineering education. The Engineers' Council for Professional Development is responsible for accrediting the curricula of engineering schools and colleges. The ECPD will analyze the recommendations of the final report, to be submitted by the ASEE in late 1966 or early 1967, in relation to the procedures and objectives of accreditation of engineering education.² According to Professor L. E. Grinter of the University of Florida, and current president of the ECPD, "Only after the most careful deliberation involving representatives of professional engineering groups would consideration be given to significant changes in the current form or procedures or objectives of accreditation of engineering curricula."³

AIMS OF GOALS STUDY COMMITTEE

The Goals Study Committee of the ASEE set about its work of studying engineering education under the direction of the following aims:

"1. To determine the basic educational needs and goals of engineers, not only for the immediate future but also for the decades ahead. These basic needs should be related to fundamental scientific principles and processes that will not be invalidated by changing practices and arts. Basic needs are also dependent upon a sound general educational background.

2. To delineate the scope of education necessary to fill these needs that can best be accomplished at the undergraduate and graduate levels.

3. To study the adequacy of present engineering education and to recommend improvements.

4. To investigate the need for post-baccalaureate programs leading to professional degrees as supplements to the traditional academic degrees, and to the role of extension, part-time and off-campus programs.

5. To recommend levels of education at which accreditation might be conducted for opti-

mum upgrading of curricula without violation of academic freedom.

6. To consider seriously the role in the engineering and scientific community of students who terminate their education with bachelor's degrees and those who graduate from technical institutes or junior colleges.

7. To review and define engineering consistent with today's technology. Existing education programs, professional societies, and professional registration activities should be viewed as a picture of the past and should not inhibit recommendations for changes."⁴

The implementation of the above aims was carried out by visiting more than 175 academic institutions, conducting a survey of more than 4,000 engineering graduates in industry, and by soliciting and receiving reports from professional societies, government study groups and industrial study groups. The results of these investigations are manifest in the Recommendations the Goals Committee of the ASEE has made in their Preliminary Report.

RECOMMENDATION

"The steadily rising utilizations of engineering manpower in the United States and the rising aspirations of individual students for higher levels of education, indicate that a substantial expansion of the national enterprise in engineering education must be planned for the next decade.

"Past and present trends justify the prediction that by 1976 the annual rate of graduation will be 75,000 bachelor's degrees, 40,000 master's degrees, and 6,000 doctorates. It is likely that as many as 40 institutions not now offering doctorate programs in engineering will be doing so by 1976, and that present programs will have grown steadily. Financial support of research in engineering schools must keep pace with this growth. The U.S. total was \$160 million in 1963 and should increase to about \$700 million by 1976. New demands on practicing engineers will require increasingly higher levels of professional competence, fuller preparation to accept new and varied responsibilities, and broader acquaintance with the many interrelated facets of modern life. In view of these and other considerations, the Goals Study recommends that:

1. The first professional degree in engineering should be the master's degree, awarded upon completion of an integrated program of at least

¹ Copies are available from the American Society for Engineering Education, Dupont Circle Building, 1346 Connecticut Ave., N.W., Washington, D. C. 20036 (\$1 per copy, 111 pages).

² "Information on Goals in Engineering Education," *Civil Engineering*, Vol. 36, No. 2, February, 1966, p. 77.

³ Ibid.

⁴ "Goals of Engineering Education", Preliminary Report, American Society for Engineering Education, October, 1965, p. 4.

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MECH MISS . . .



Miss Mary Haas

This month's Mech Miss is a pretty 18½ year old sophomore from Great Neck, L.I., N.Y.

Mary is a history major whose favorite pastime is swimming.

Here at G.W., this 5' 2½" coed is an active member of The Alpha Epsilon Phi Sorority, a Panhel delegate and a member of the Hall Council at the Superdarm.

For vital information, dial EN-BE-EE.





CAMPUS NEWS



THETA TAU PLEDGES

CLASS: SPRING '66

by Doug Lowe

In the past few issues of **MECHELECIV**, we have been making an effort to inform the engineering undergraduate students of the purposes and goals of Theta Tau Fraternity. Some of our attempts have been serious and straightforward; others have been less than serious while still trying to present the essential aspects of the Fraternity.

Perhaps the message is best expressed by Martin Felker in his letter to potential members: A fraternity is a serious and/or social gathering of fellows who have enough in common to want to act together in brotherhood. It sounds academic, but that's just what Theta Tau is: men who have gotten together at picnics, at meetings, at banquets, at dances, or on the softball field to enjoy each other's company and to have a good time. In time of need (exams, term papers, lab reports) any brother may be called upon to render his utmost and humble services. We are basically a social fraternity, but great emphasis is placed on professionalism, either directly by presenting outside professional speakers or indirectly by exposure to our own brothers who are already professional engineers. Consequently, even though our Q.P.I. membership requirement is only 2.00 or better, we do applaud engineering students who take their studies seriously. Engineers by nature are economy-minded and we try to balance our program in such a way that the costs are held to a minimum. Membership is not limited to only full-time single students. In

fact, many of our functions cater to part-time and married students.

Of the men who considered the thoughts which were presented to them, ten were asked to join us. We believe they are ten men who are strong in character now and have very high potential for development as successful professional engineers later. We certainly will try to help them reach their goals.

These are the men who will be recognized as new members of Theta Tau after the conclusion of their pledging period and their initiation on April 23. From left to right:



Ali Abu-Taha, Andy Kapust, Alan Steiner, Tim Stegmaier, Miguel Saab, Pat Cadwallader, Sandy Lewis, Guy Goodard, and Lee Danisch. Missing in the photo is John Lindsey.

Is there something special about these men? Yes, they will soon be brothers in Theta Tau.

HONORS LIST FALL SEMESTER, 1965

The Faculty of the School of Engineering and Applied Science has provided for the recognition of meritorious scholastic achievement by the display and publication of an Honors List. The students whose names appear below have met all the requirements established by the Faculty for this honor. On behalf of the Faculty, it is my pleasure to extend congratulations to these superior students.

As a matter of possible general interest, the Honors List contains "... in alphabetical order,

Ayre, Robert W.
Belford, Kenneth R.
Carrano, Thomas
Cavanaugh, John T.
Chandler, James M.
Cook, Michael S.
Cox, Barrington
Crotty, Francis C., Jr.
Danisch, Lee A.
Dhinakar, S.
Diehl, James M.
Everard, William H.

Foote, Kenneth G.
Friedlander, Jan E.
Harmann, Lowell K.
Herman, William A.
Huff, David L.
Hurley Robert E.
Johnson, Paul B.
Johnson, Robert W.
Kaul, Pradman P.
Keltie, Robert J.
Kuhn, Harry A., Jr.

LeBeau, Francis S.
Manolatos, Telemachos J.
McSpadden, Thomas E.
Moriarty, James M., Jr.
Murray, Edward R.
Nieto, Ricardo J.
Otto, Edwin R.
Proctor, Joseph L., III
Rohrer, Michael W.
Rutiser, William A.
Saab, Miguel C.

Saidman, Perry J.
Sanford, Hartwell A.
Schroeder, Curtis A.
Sekhar, S.
Spindel, Karen S.
Standifer, Orville, Jr.
Starke, John W.
Steiner, Alan P.
Taylor, Douglas M.
Walker, Andrew M.
Weaver, Donald B.

the names of candidates for an undergraduate degree in engineering whose scholastic achievement satisfies all of the following requirements:

- The candidate's quality-point index is equal to or exceeds 3.00 on 15 semester hours in one semester.
- No grade below "C" has been received during the qualifying period.
- No disciplinary action has been taken in respect to the student."

How do you test a product that's six miles long? Or reduce the size of something almost too small to see?

TOUGH jobs...typical of the engineering work being done day after day at Western Electric, the manufacturing and supply unit of the Bell System. And you can have a hand in solving problems like these.

The six-mile product was a complete telephone cable. How to test it before it was buried underground — before modifications, if necessary, became time-consuming and expensive? The solution was to design an "artificial cable" — a model a few inches in length whose electrical characteristics matched those of the full-size cable. In this way, engineers learned which type of cable would do the job best, how many repeater stations would be needed, and where repeater equipment should be installed. Artificial cable lets us anticipate and solve many other problems ... before they ever arise.

The small product was a thin film circuit — an electrical path only thousandths of the thickness of a human hair. How do you design equipment to make certain parts thinner, to increase resistance, without altering other parts? WE engineers used capillary action to bring liquid only to the desired areas — and electrolysis brought about the precise reduction. It's quick in the telling, but it took sharp minds to arrive at this solution.

Western Electric needs more sharp minds. Whatever your field is, there are plenty of opportunities for interesting work, and for rapid advancement. If you set the highest standards for yourself and seek a solid future — we want to talk to you! Be sure to arrange a personal interview when the Bell System recruiting team visits your campus. And for detailed information on the opportunities that await you, get your copy of the Western Electric Booklet "Opportunities in Engineering and Science" from your Placement Officer. Or write: College Relations Staff Manager, Western Electric Co., Room 2510A, 222 Broadway, New York, N. Y. 10038. An equal opportunity employer.



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TECH NEWS



NEW ONE-INCH CRT



Du Mont Electron Tubes has introduced a new one-inch cathode ray tube for applications where compact size is required together with unusual performance characteristics for such a small tube.

The new CRT measures 1" in diameter, 3.2" in length and has a usable face of 0.8" in diameter.

The lightweight, extremely compact tube is manufactured to extremely tight mechanical tolerances.

Designed primarily for photographic purposes, excellent resolution and low deflection defocusing are achieved although employing electrostatic deflection and focus.

Spot size is held to .007" which is unusual in a tube of such small dimensions.

Faceplate of the tube is made of special purpose, optically-treated glass which is coated with a blemish-free phosphor, both in turn contributing to improved resolution, reduced spot size, and increased brightness.

Beam acceleration employs relatively low voltages which also enhances deflection sensitivity.

This new CRT will find many special-purpose applications in airborne use or where packaging or panel-instrument density are primary considerations.

600,000 LB. ROTOR FOR STEAM TURBINE GENERATOR



After five days in the heating furnace where it was exposed to temperatures up to 2300 degrees Fahrenheit, the ingot is removed from the furnace ready for forging.

Destined to become one of the largest generator rotors ever manufactured from a single forging—which, in turn, was made from the largest and heaviest vacuum-degassed ingot ever poured—a giant steel forging is being readied for shipment at Bethlehem Steel Corporation's Bethlehem, Pa., plant.

The ingot from which the rotor was forged and machined weighed 638,400 pounds, requiring the contents of five electric furnaces to produce the desired quantity of nickel-molybdenum-vanadium alloy steel.

Machined from the vacuum-degassed steel, which is free from entrapped gases and impurities which might impair the quality of the forging, the completed rotor will have a shipping weight of 318,000 pounds and an overall length of 47 feet. It is scheduled for delivery to General Electric Company this fall. At G.E.'s Large Steam Turbine-Generator Department in Schenectady, N. Y., the rotor will be completed for installation in the steam-turbine-driven electric generator at Niagara Mohawk Power Corporation's Nine Mile Point atomic power plant near Oswego, N. Y.

The rotor will turn at the rate of 1,800 revolutions per minute, and the generator will be capable of producing 620,000 kilowatts of electricity—enough to supply the electrical energy for the needs of the State of Hawaii or New Hampshire.



After its final machining, the rotor forging is being prepared for removal from the huge lathe on which it was turned to its specified dimensions. Next step will be final testing. From here it will go to the customer for finish machining and assembly.

LASERS MAY REPLACE SPACE VEHICLE UMBILICALS

Beams of invisible laser light some day may replace the thousands of wires that now carry checkout signals into a space launch vehicle before lift-off.

Presently, a thick umbilical holds the wires carrying power and information from the gantry into a launch vehicle's electronic systems during the count-down. This umbilical has to transfer data into the vehicle up until lift-off but then be

THE MECHELECIV

separated without hindering the launch. IBM, under contract with the National Aeronautics and Space Administration's John F. Kennedy Space Center, is exploring the possibility of replacing portions of the heavy umbilicals with a laser communications system.

Lasers generate an intense, narrow beam of infrared light that can be modified like a radio wave to carry information but they do not interfere with other communications channels like radios. In fact, because it generates a higher frequency than radios, theoretically a laser beam can transmit more information than a radio wave.

UMBILICALS ARE ELECTRICAL SUPPLY LINES

Harnessing laser beams to send off space vehicles would eliminate much of the complicated equipment presently needed to disconnect a launch vehicle's thick umbilical at the moment of firing. This umbilical consists of some 800 cables. During the countdown before launch, it carries signals to check such things as systems in the launch vehicle and its spacecraft, the guidance computer's clock, sensing and control devices, and can carry an astronaut's voice. Immediately prior to lift-off, these connections must be severed so that the umbilicals can fall away.

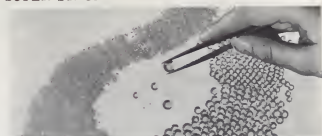
The laser system being built for NASA's John F. Kennedy Space Center, will test the feasibility of replacing some of these connections with laser beams. (A few wires to carry electrical power will probably always be retained.) The demonstration system will use eight tiny lasers to replace 112 wires, including two voice links. Since the laser system is "doubly redundant" for high reliability, four lasers will actually be doing the work, each of them replacing 28 wires.

The rapid improvements being made in lasers may eventually make it possible for a few lasers to replace almost all of the 800 cables, containing several thousand individual wires, used in the umbilicals of space vehicles.

The lasers to be used in the system are made of tiny crystals of the semi-conductor compound gallium arsenide, and are operated simply by passing an electrical current through them. The lasers to be used have a peak power output of a few watts.

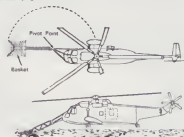
The demonstration system to be built will not be used with an actual space vehicle, but with a mock-up which will simulate a space vehicle's motion during the few critical seconds between ignition and lift-off. Signal transmissions to and from a space vehicle occur before the space vehicle lifts off, but for a few seconds after its huge engines ignite, it does not leave its pad. During this time, the smoke of the burning fuel may block the laser's beam of light and the vibration of the space vehicle moves the laser beam's target slightly. The NASA contract calls for study of these problems with an actual laser system during tests scheduled for the first quarter of 1966.

SUPER-STRONG GLASS BEADS



High-strength glass beads are being marketed by Corning Glass Works in seven sizes ranging from 1/64-inch to 3/8-inch. Crushing strengths of the hard, inert glass spheres are as high as 125,000 p.s.i. The beads have a wide range of applications in the chemical, metals finishing and plastics industries as well as other fields. Typical applications are as grinding and burnishing media or as filler material.

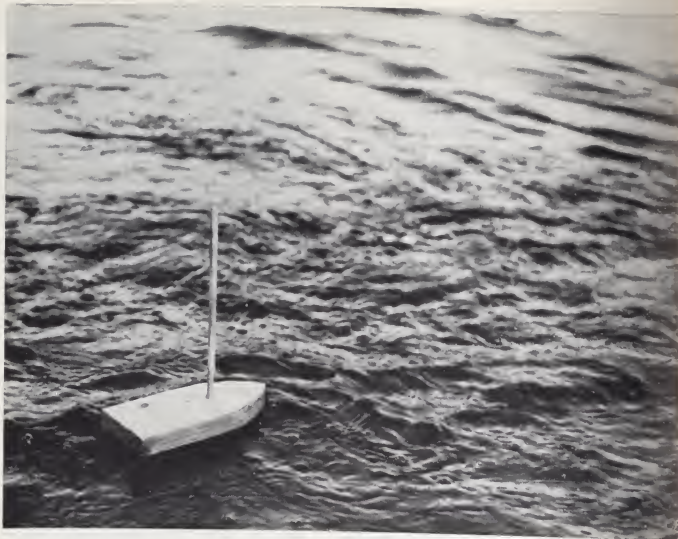
SCOOP ATTACHMENT FOR HELICOPTERS MAKES RECOVERIES FASTER AND SAFER



Present helicopter rescue and recovery operations require that either the helicopter hover dangerously close to the persons or objects being retrieved or that a line be lowered to them. In the latter case, one of the helicopter crew must often descend on the line to properly secure it. In each type of operation, the helicopter pilot lacks a clear view of the object being retrieved and therefore has difficulty properly positioning the aircraft. The combination of these factors makes recovery operations difficult and dangerous.

NASA's solution is a rigid boom and net attached to the front of the helicopter that can be used as a scoop to retrieve objects from difficult locations. Since the boom is in front, the pilot has the subject in view at all times and can position the aircraft more readily. The boom can be pivoted to bring the recovered object to the side hatch of the helicopter so that no member of the crew need leave the aircraft.

The boom is made from tubular aluminum in the form of a cantilevered truss. It is attached to the front of the helicopter and offset toward the side with the entrance hatch. The boom pivots in the center so that the net may be brought back to the side hatch for retrieval or storage. The basket is made from plastic covered wire net which will not float and which is resistant to saltwater corrosion.



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A

WHAT IS OPERATIONS RESEARCH?

by Majid Daneshmand

SOME DEFINITIONS

Operations research can be defined in many ways. Perhaps the simplest way is first to define operations. Philip M. Morse offers the following definition: "an operation is a pattern of activity of men or of men and machines, engaged in carrying out a cooperative and usually repetitive task with pre-set goals and according to specified rules of operation."¹ Operations research then is the study of operations. Thomas L. Saaty states that the usual definition of operations research is: "an aid for the executive in making his decisions by providing him with the needed quantitative information based on scientific methods of analysis."² He also quotes others who define operations research as "quantitative common sense," or "research into operations." Because he believes that operations research is difficult to define and that no one yet has written a satisfactory definition, Saaty himself prefers: "operations research is the art of giving bad answers to problems to which otherwise worse answers are given."³

WHAT O.R. IS NOT

Another way of providing a basis for understanding what operations research is, is to state what it is not. Operations research is not management consulting or industrial engineering or market analysis, even though it is related to these fields. There are two main differences. First, there is the fact that operations research relies almost entirely upon mathematics, as was suggested by Saaty's stating that the operations analyst was to provide quantitative information. Secondly, the operations analyst himself is not concerned with decision making, but only with gathering information upon which others can base their decisions. The analyst in operations research relies heavily upon probability theory for one of his main tasks is to predict what would be the results of changes in an operation. By quantitatively analyzing the effect of the various ways in which an operation could be changed, the operations analyst provides the decision maker with precise information upon the basis of which he can evaluate the desirability of various alternatives.

O.R. IN THE PAST

Perhaps the best way to understand operations research is not to define it, but to tell something about its history.

Although operations research was not known by that name until World War II, there were men who employed the basic methods of operations research in solving problems of production before that time. A pioneer was Frederick W. Taylor, who used mathematical analysis to determine the weight of material which the worker should carry in his shovel in order to be most efficient. In 1916 Frederick W. Lanchester applied quantitative

analysis to military strategy in order to determine the relationship between victory and numerical and weapon superiority. In the 1930's Horace C. Levinson applied the methods of operations research to advertising and the techniques of merchandising.

O.R. IN WW II

The greatest development of operation research, however, occurred during World War II when the gravity of the crisis made men aware of the fact that they must utilize every possible means of defeating the enemy. Two examples can be used to show how operations research was applied to problems of warfare. The English were alarmed because they could not attain a high degree of accuracy in bombing. After several others had unsuccessfully approached the problem of bombing accuracy, it was assigned to a team of operations analysts. They analyzed the problem in terms of the relationship between accuracy, the number of aircraft in the formation, dimensions of the formation, number and type of bombs carried, speed and altitude of the planes, etc. As a result of their findings, the accuracy was increased from 15% in 1942 to more than 60% in 1944.⁴

Another problem was that of the detection and destruction of enemy shipping and submarines. On the basis of studies done by operations analysts, it was concluded that Allied aircraft would be more effective if patrol was done on a systematic rather than a random basis. The new method was very effective against German ships.

IN TODAY'S MILITARY

Because operations research was so effective during World War II, operations analysts have continued to serve all branches of the services in the United States. The groups are: the Operations Evaluation Group (Navy), the Operations Analysis Group and the RAND Corporation (Air Force), and the Operations Research Office (Army). The Weapons Systems Evaluation Group, a part of the Institute for Defense Analysis, serves the Joint Chiefs of Staff. There are also other smaller groups. The British use similar groups in their military services.

IN INDUSTRY

After the war, industry became aware of the effectiveness which operations research groups had demonstrated in serving the military. In the United States, the rapid expansion of the economy which had taken place during the war created a need for more effective means of competition. The British, on the other hand, needed recommendations which would help them rebuild an economy whose efficiency and capacity had been heavily damaged during the war. In both countries,

--Continued on Page 22

WHAT IS OPERATIONS RESEARCH—Continued

it was realized that the techniques of operations research could be applied to industry as well as to warfare.

The British government also saw the value of operations research and applied it to the study of those parts of the economy which were nationalized. Businessmen in the United States adopted operations research techniques later than did the British because they continued to rely upon the older methods of management consulting and industrial engineering. Aircraft corporations such as Convair and Lockheed were among the first to make operations analysts a part of their staff. Now a wide number of industries employ such groups to study transportation, communication, agriculture, merchandising, and manufacturing. Some of the larger companies employing operations analysts are U.S. Rubber, Sun Oil, and Du Pont.

IN EDUCATION AND GOVERNMENT

The scope of matters which are being treated with the techniques of operations research is constantly expanding. Saaty suggests that the ultimate scope of the field is almost unlimited. He suggests that operations research could be applied to even education. After doing statistical studies of the times required to learn a subject when it is presented in various ways, the operations analyst's finding could be used as the basis for the determination of the most efficient way of presenting a subject. For instance, anatomical terminology perhaps could be simplified if it were found that the simplification made a reduction in the student's learning time. Saaty also sees a need for the increased utilization of operations research in government. He feels that the statesman must be given more precise knowledge of the consequences of his actions than now exist if he is to formulate policies that are suited to the complexity of the modern age.

O.R.'S PROBLEM SOLVING TECHNIQUE

The scope of operations research would seem to be unlimited because the basic procedure of the field can be applied to almost any matter. The task of the operations analyst is to quantify all data relevant to the solution of a given problem or the attainment of a given goal. Saaty outlines the steps by which the operations analyst arrives at the quantification of data as

follows: (1) examination of the objectives which are presented to him to be fulfilled; (2) determination of the type of data necessary to the solution of the problem, their availability, and how readily they are obtainable; (3) generation and examination of the various practical methods to decide which may lead to the desired ends; (4) selection and application of those methods which seem best to attain the objective; and (5) communication without bias of his findings to the decision maker.⁵

COMPLICATIONS

The operations analyst is confronted with many problems. First, in order to analyze a problem in a given field, the operations analyst must have a sound knowledge of that field. For instance, in the case of the bombing accuracy study, the analysts had to understand aircraft and military strategy. The task of the operations analyst becomes even more complex if several fields are related to the objective which his work is to help to attain. Secondly, as Glen D. Camp states, "in many cases sponsors of operations research projects are able to state their objectives only in rather vague generalities if at all."⁶ Hence, the analysts become involved in interpretation of objectives and thus to a certain extent become part of the decision making process in which they are not supposed to participate. A final difficulty is one which confronts operations research as a whole. Because the basic assumption of the operations analysts is that human behavior is predictable and subject to quantification, the field will encounter opposition from those who maintain the scientific method cannot be applied to the study of man.

FOOTNOTES

¹Operations Research Center, *Notes on Operations Research*: 1959 (Cambridge, Massachusetts: The Technology Press, 1959), p. 1.

²Thomas L. Saaty, *Mathematical Methods of Operations Research* (New York: McGraw-Hill Book Co., Inc., 1959), p. 3.

³*Ibid.*, p. 8.

⁴*Ibid.*, p. 9.

⁵*Ibid.*, p. 16.

⁶*Ibid.*, p. 4.

⁷J. Sayer Minas, "Science and Operations Research," *Proceedings of the Second International Conference on Operational Research*, J. Banbury and J. Maitland (ed.) (New York: John Wiley & Sons, Inc., 1961), p. 29.

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they may be considered by the Goals Committee of the ASEE as it prepares the final report. At the American Society for Mechanical Engineers' Annual Meeting in Chicago, the members of the Society, who are also heads of mechanical engineering departments, held a preliminary discussion on the Recommendations. They felt that comments and opinions on certain questions could be used as a background for further discussions that would ultimately lead to the establishing of the ASME position on each of the 14 Recommendations. Two of these questions follow.

"(A) What Place will the proposed Four-Year B.S. have in the practice of engineering? Recommendation No. 2, coupled with Section III-A-6, suggests that the credit hours per semester be reduced about twenty percent from the present norm of 17.5 to 14. The recipient of the bachelor's degree based upon a four-year program that contains only eighty percent of present curricula will be substantially deficient in courses in analysis and design, which must logically follow the preparatory courses in the engineering sciences. There will be practically no opportunity for presenting any specialized courses during the first four years. What place will this fill in the spectrum of engineering opportunities? How can this proposed four-year B.S. fill a practical need in the market place?

(B) How will conferral of the first engineering degree at the M.S. level affect the demand and supply of engineers? Would not the adoption of Recommendation No. 1 reduce the output of "professional" engineers because of present restrictions in most good colleges of engineering that limit enrollment for graduate study to the upper one-half of graduates with bachelor's degrees? Also, Recommendation No. 1, coupled with the suggestion for a twenty per cent reduction in credit hours per semester, appears to many to be tantamount to awarding a Master of Engineering degree to a student who is exposed during a five-year period to little if any more formal education than is now encountered in present four-year curricula. If so, the output of qualified "professional" engineers would be substantially reduced without an accompanying improvement in the quality of these graduates."⁶

These questions were sent to Dean Hawkins, the director of the undergraduate phase of the Goals Study, for his comments and opinion. In his reply he stated:

"The great help your committee, department heads, and others can give us now is to study each Recommendation and report to us in the following fashion: 'Recommendation No. X. If the study group means..... Then we agree with the recommendations; otherwise we disagree. Or, we disagree with Recommendation No. X for the following reasons: 1..., 2..., 3...'

This is the type of information which will be of greatest help to us. Dissertations on the philosophy of four-year versus five-year programs are interesting but do not come to grips with the problems before us.

The answers to your questions (A) and (B) can only be found in the 'Market place' if the five-year plan is adopted."⁷

On the basis of Dean Hawkins' comments and their preliminary discussions in Chicago the ASME is preparing its report on the Recommendations to help the Goals Study Committee in preparing the final report. Similar procedures are being carried out by the other professional societies in informing the Goals Committee of their thoughts on the Recommendations. The comments and opinions of engineering students are also desired by the Goals Committee since it is students that will be on the receiving end of these Recommendations if they are adopted by the ECPD and subsequently by the engineering schools and colleges throughout the United States.

WHAT THE STUDENT CAN DO

Do you want the bachelor degree to be called an "introductory degree" with only the masters degree accepted as a "professional" degree? Will the downgrading of the B.S. degree affect the standing of the present B.S. degree you are striving for? Will the new "professional" M.S. degree program be any more than the old five-year undergraduate B.S. programs in engineering that have practically disappeared? Should the "professional" M.S. degree be given as much weight as the present Master of Science degrees? Will you be satisfied by the "market place" answer Dean Hawkins offers for questions of the above type? If you want your voice heard on these questions or others of your own making, you should address your comments to:

Dean Martin A. Mason
School of Engineering and Applied Science
George Washington University
Washington, D. C. 20006.

Or, if you want your comments published you can leave them in the Mecheleciv mail box in the Davis-Hodgkins House, 731 22nd St., N.W. In either case your comments will be forwarded to the ASEE Goals Committee. It is suggested that Dean Hawkins' formula for presenting comments would bring the best results. If you feel you want to write do not delay. The Goals Committee wants your comments as soon as possible, definitely before June 1st. Here's your chance to be heard on the future course of engineering education. If you fail to speak up now your future complaints may be too late.

Pencils, envelopes, writing paper, stamps anyone? REMEMBER! THE DEGREE YOU SAVE MAY BE YOUR OWN!

⁶ "Goals of Engineering Education part 3: ASME's plan," *Mechanical Engineering*, Vol. 88, No. 2, February, 1966, p. 41.

⁷ *Ibid.*

THE

SHAFT



When I was but a little lad
Upon my mother's knee,
She used to ask me, "Son of mine,
What will you one day be?"
And I, with my slide rule in my
hand —

The toy I loved so dear --
Would answer, "Mamma, you
should know,
I'll be an engineer!"
While other little boys my age
Were reading fairy tales,
I'd bug my little eyes out
Over books of logs and scales.
The formulae they stuffed me
with

Were not sweet milk and meal --
I'd eat equations X times Y --
How good they made me feel!
And so it was that pi to me
Was nothing that I ate;
I knew it equaled three one four
So I'd leave it on my plate.
The calculus and algebra
Became my bone and joint;
What difference did it really
make

If my head came to a point?
Then, as it is in every life,
A kindred soul I spied --
I wooed her with exponents,
And with fractions she replied.
Her smile was quite symbolic,
Her figure hyperbolic;
Her lips were hysteresis loops,
her smile was quite symbolic.
Our wedding was a joining
Of two mathematical wizards.
We knew all calculations
From alpha to the iizzards.
Yet with all this wealth of knowl-
edge

No matter how we try,
The operation we do best
Is just to multiply!

* * *

I walked into the barbershop,
The sign was very queer,
"During alterations
We will shave you in the rear."
* * *

A sign in a local store read
as follows: "Our lingerie is the
finest. Smart women wear noth-
ing else."

The house guests were assem-
bled with their hosts in the living
room after dinner, chatting pleas-
antly, when the five-year-old
daughter of the host appeared
suddenly in the room, her clothes
dripping with water. She could
scarcely articulate, so great was
her emotion, and the parents rose
in consternation as she entered:
"You-you," the little girl bab-
bled and pointed to the male of
the house, "You're the one who
left the seat up."

* * *

A young UM student was speed-
ing across campus when he was
stopped by a campus cop.

"Let's see your license," said
the cop.

The student remained silent.
"What's your name?"

Still without a reply, the stu-
dent reached casually over to
the glove compartment, opened
it and pulled out a stick of gum.
Unwrapping it he rolled the tin-
foil into a ball and handed it to
the cop.

"Here," he said. "This silver
bullet should explain who I am."

* * *

Little Girl: "Mother are there
skyscrapers in heaven?"

Mother: "No dear, it takes
engineers to build skyscrapers."

* * *

"Waiter, there's a fly in my
soup."

"That's very possible, sir,
the chef used to be a tailor."

* * *

A young lady with a touch of
hay fever took with her to a din-
ner party two handkerchiefs, one
of which she stuck in her bosom.
At dinner she began rummaging
to right and left in her bosom for
the fresh handkerchief. En-
grossed in her search, she sud-
denly realized that conversation
had ceased and people were
watching her, fascinated.

In her confusion she mur-
mured, "I know I had two when I
came."

He watched, fascinated as his
wife smoothed cold cream over
her face. "Why do you do that?"
he finally asked.

"To make myself beautiful,"
answered his wife, who then be-
gan removing the cream with a
tissue.

"What's the matter?" he asked.
"Giving up?"

* * *

The young reporter dashed into
the editor's office and shouted,
"I have a perfect news story!"

The editor looked up from his
proofs and asked, "Man bites
dog?"

"No," the reporter said, "Bull
throws professor!"

* * *

Mother (putting Junior to bed):
"Shh . . . the sand man is com-
ing."

Junior: "For fifty cents I
won't tell Daddy."

* * *

"You'll be poor and unhappy
until you graduate from college,"
said the fortune teller to the
engineer.

"And then what?" asked the
engineer hopefully.

"You'll be used to it by then,"
answered the fortune teller.

* * *

After a brief visit to a fel-
low engineer's home, Jimmie
was amazed at how often his
friend's grandmother would read
the Bible. Before leaving, he
asked why the elderly woman
took such a deep interest in the
book. "Cramming for the finals,"
was the reply.

* * *

Drunk: "Hi Lady, you got two
ver' beautiful legs."

Girl (snapping): "How would
you know?"

Drunk: "I counted 'em."

* * *

They laughed at Watt, too,
until he invented the Watt
Schamallit.

THE MECHELECIV



University of Rochester Library Tower as seen by the famed photographer Ansel Adams

Have your cake and eat it

Suggestion to Ch.E.s, M.E.s, and other engineers:

The University of Rochester has long committed itself to the pursuit of academic excellence and long ago attained success in that quest. Likewise, with a somewhat different conception of higher education, has the Rochester Institute of Technology earned high regard. The two institutions are quite unrelated to each other or to us, except that their fortunate presence in Rochester provides opportunity for those who join us with fresh baccalaureates to proceed right on course with the next formal stage of professional or business preparation. In Kingsport arrangements are offered by the University of Tennessee Graduate School and East Tennessee State University.

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SIX G-E J93 ENGINES push USAF XB-70 to MACH 3.



JACK WADDEY, Auburn U., 1965, translates customer requirements into aircraft electrical systems on a Technical Marketing Program assignment at Specialty Control Dept.



PAUL HENRY is assigned to design and analysis of compressor components for G.E.'s Large Jet Engine Dept. He holds a BSME from the University of Cincinnati, 1964.



ANDY O'KEEFE, Villanova U., BSEE, 1965, Manufacturing Training Program, works on fabrications for large jet engines at LJED, Evendale, Ohio.

A PREVIEW OF YOUR CAREER AT GENERAL ELECTRIC

Achieving Thrust for Mach 3

When the North American Aviation XB-70 established a milestone by achieving Mach 3 flight, it was powered by six General Electric J93 jet engines. That flight was the high point of two decades of G-E leadership in jet power that began when America's first jet plane was flown in 1942. In addition to the 30,000-pound thrust J93's, the XB-70 carries a unique, 240-kva electrical system that supplies all on-board power needs—designed by G-E engineers. The challenge of advanced flight propulsion promises even more opportunity at G.E. GETF39 engines will help the new USAF C-5A fly more payload than any other aircraft in the world; the Mach 3 GE4/J5 is designed to deliver 50,000-pound thrust for a U.S. Supersonic Transport (SST). General Electric's involvement

in jet power since the beginning of propellerless flight has made us one of the world's leading suppliers of these prime movers. This is typical of the fast-paced technical challenge you'll find in any of G.E.'s 120 decentralized product operations. To define your career interest at General Electric, talk with your placement officer, or write us now. Section 699-16, Schenectady, N.Y. 12305. An Equal Opportunity Employer.

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